Survey of Juvenile Salmonids of Gravity-Fed Irrigation Ditches, Nicola and Coldwater River Valleys, 1985

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SURVEY OF JUVENILE SALMONIDS OF GRAVITY-FED IRRIGATION DITCHES, NICOLA AND COLDWATER RIVER VALLEYS, 1985

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ABSTRACT

Fleming, J. O., J. S. Nathan, C. McPherson, and C. D. Levings. 1987. Survey of juvenile salmonids in gravity-fed irrigation ditches, Nicola and Coldwater river valleys, 1985. Can. Data Rep. Fish. Aquat. Sci. 622: 47 p.

Surveys were conducted of juvenile salmon populations in gravity-fed irrigation ditches in the Nicola and Coldwater valleys during July to October 1985. Twelve ditch systems were mappe and lengths were estimated by surveys and aerial photographs. In one system near Merritt approximately 4100 chinook (mean density 0.12 $^{-2}$) and 3700 rainbow trout (mean density 0.18 m^{-2}) were present downstream of a fish screen and were assumed lost when dewatering occurred in October. Some salmonids were observed rearing upstream of fish screens. Ditches connected with natural springs and abandoned irrigation ditches could possibly be expanded, reconnected, and used as rearing habitats for juvenile salmon.

RESUME

Fleming, J. O., J. S. Nathan, C. McPherson, and C. D. Levings. 1987. Survey of juvenile salmonids in gravity-fed irrigation ditches, Nicola and Coldwater river valleys, 1985. Can. Data Rep. Fish. Aquat. Sci. 622: 47 p.

De juillet à octobre 1985, on a effectué des relevés des populations de saumons juvéniles dans des fossés d'irrigation alimentés par gravité des vallées des rivières Coldwater et Nicola. Douze systèmes de fossés ont été cartographiés et leurs longueurs ont été déterminées par relevés et photographies aériennes. Dans un système près de Merritt, environ 4 100 saumons quinnats (densité moyenne: 0,12 m^{-2}) et 3 700 truites arc-en-ciel (densité moyenne: 0,18 m^{-2}) étaient présents en aval d'un grillage à poisson; suite à l'assèchement en octobre, on a supposé que ces salmonidés étaient morts. On a observé un certain nombre de salmonidés en amont des grillages à poisson. Les fossés reliés à des sources naturelles et les fossés d'irrigation abandonnés pourraient être allongés, raccordés, et utilisés comme aires de croissance pour les saumons juvéniles.

INTRODUCTION

The Nicola River system is used by both resident and anadromous fish especially chinook (Oncorhynchus tshawytscha), coho (O. kisutch), and pink salmon (O. gorbuscha), and steelhead trout (Salmo gairdneri). A number of human activities are closely associated with the river system. Examples of these are a gravel washing operation, the Merritt sewage treatment plant, and irrigation of agricultural areas (Starr 1978). The most important consumptive human activity which affects water levels in the Nicola system is its use as a source of irrigation for about 11,600 hectares of land used to grow forage for cattle feed (O'Riordan, 1981). Water rights held by ranchers and Indian Reserves were acquired before an effective water management plan had been developed leading to conflicts between user groups and fisheries interests. Wing dams, constructed to divert water into irrigation ditches, can obstruct normal river flows. Juvenile salmonids rearing in the river are swept with the unscreened diverted water into the farmer's fields or are attracted to the habitat of the quieter ditch water for use as rearing areas. Fish in the ditches can become trapped and killed during periodic dewatering over the summer or at the season's end when ditches are blocked off. These losses from the juvenile salmonid population have been of primary concern for many years.

In 1984 the Department of Fisheries and Oceans, Fisheries Research Branch, began a study of juvenile salmonids in the Nicola River system, in part to determine the effects of low flows on overwintering populations. As part of the study, various irrigation ditches were surveyed. Initially, the objectives were to identify and map water extraction sites and drainage ditches in the lower Nicola watershed, and to determine what species were using these off-channel habitats for rearing purposes. Subsequently, the scope of the work was expanded to include estimation of the number of salmonids rearing in the open-channel irrigation ditches and to review the status of ditches in the lower Nicola and Coldwater Rivers and their tributaries. The study was conducted from July to October 1985.

STUDY AREA

The Nicola River flows for approximately 193 km through the dry south central interior of B.C. to join the Thompson River at Spences Bridge. Its principal tributary is the Coldwater River which joins at Merritt. Spius Creek flows into the Nicola at a point approximately 18 km further downstream (Figure 1). The Nicola basin consists of a high plateau intersected by deep alluvial valleys. The vegetation is predominantly Ponderosa pine and bunchgrass.

Air temperatures during the summer are warm with a July average of 17.5°C and extremes reaching 40°C. Water temperatures of 23°C were recorded in the Nicola River during the study. The warm climate, combined with low precipitation (230-450 mm per year), has the effect of reducing the flow in the Nicola River so that heavy demands for water can cause serious depletion during dry years.

The major spawning area for chinook salmon is the section of the Nicola from Merritt to Spius Creek, but about 25% spawn upstream of Merritt or downstream of Spius Creek. The principal spawning grounds for coho are in the Coldwater River and Spius Creek, although there is limited spawning in the Nicola between Merritt and Spius Creek (Kosakoski & Hamilton 1982).

The sites sampled in the study are shown in Figure 1. Most of them were in the area between Merritt and Spius Creek but two were on the Coldwater and one further downstream on the Nicola.

FIELD SAMPLING PROGRAM

i) Survey Methods and Timing

Initial surveys in 1985 were conducted by "floating" the Nicola River, in an inflatable boat, from Merritt to Stirling Ranch located approximately 2-2.5 km upstream of the Spius Creek confluence with the Nicola River. On July 10, water withdrawal and diversion sites, drainage ditches, creeks and sloughs were located on maps for sampling during future visits. Low water levels in the Nicola River in summer and autumn made "river floats" difficult and subsequent surveys were carried out by road and ground access.

Over the period July 23 to October 18, intermittent mapping and sampling were carried out in conjunction with other program activities in the Nicola/Coldwater area. Population estimates of salmonid in open-channel irrigation ditches were made during the weeks beginning September 18 and September 30.

Maps of the study area were traced from aerial photographs obtained from the Surveys and Resource Mapping Branch of the Provincial Ministry of the Environment. Appendix 1 lists the aerial photos used for each irrigation system mapped. The maps were enlarged to provide a working copy for use in the field where they were ground-proofed. Irrigation channels which were indistinguishable in the airphotos were then hand-drawn onto the maps as accurately as possible.

The majority of fish sampling was carried out with a Smith-Root backpack style electrofisher (Model 11A). Both "AC" and "DC" current types were used depending upon sampling objectives and habitat and water conditions with voltages used ranging from 200 to 500. The "DC" (direct current) option proved to be least traumatic for the fish and very useful with its ability to "draw" fish out of heavy cover areas and "hold" them in the electrical field near the probe, but sampling indicated it was of limited use in areas of deeper water and was not always accurate during multiple-pass population estimates. For these reasons, the "AC" (alternating current) option was the primary sampling method with the electrofisher.

Initial sampling was carried out by electrofishing the channels in an upstream direction and estimating or measuring the length of channel sampled. Both multiple-pass and single-pass methods were employed depending upon sampling

objectives. When population estimates were made, stop-nets (5 mm mesh pole seines or nylon window-screen material) were installed at the upper and lower limits of the study section. All electrofishing was carried out by a two-person crew, one to operate the electrofisher and capture fish with a screen-covered probe and one person to collect fish with a dip-net (various sizes used).

Other sample methods included the use of a 1.5 m pole seine (5 mm mesh) and 'Gee' minnow traps baited with preserved salmon roe. These methods had limited use and were employed in situations where time constraints, access and water depth were not conducive to electrofisher use.

ii) Fish Enumeration and Measurements

All salmonids captured were identified and counted and a sub-sample was measured for fork length (+/- 1 mm), using the anaesthetic 2-phenoxy-ethanol to subdue the fish. After recovery, all fish were released alive, usually directly into the Nicola River. A small number of individuals (usually sampling mortalities) were preserved in 10% formalin for species identification, age determination (scale-reading) and weights.

Population estimate sampling consisted of a series of removals of fish (i.e. multiple passes) from a known length of irrigation ditch. Estimates made during July and August did not use nets and a natural barrier to emigration was used at Site 1 on the Neale Ranch. Densities and estimates of the number of chinook salmon and rainbow trout rearing within the sample area were generated using a computer program based on the Zippin Method (Higgins, 1985) where:

$$N = T \,/\, 1-q^k$$

where:
N = estimated population size
T = total catch from "k" removals where;
k = successive samples
q = 1 - p = probability of individual not being caught
p = probability of catching an individual

Each sample site was intended to be representative of a particular section, or reach, of the irrigation channel being examined. These sections were arbitrarily set by visual examination and were selected according to channel morphology, i.e. width, depth, gradient, habitat type (i.e. cover, pool/riffle/glide composition), and accessibility.

The length of each major section of the irrigation ditch was estimated from a map of the survey area and multiplied by the density estimate (fish per meter) of fish in the sample site to provide an estimate of the total number of individuals rearing within a specific reach of the ditch. Wetted width and length of the channel at the time of sampling and total length of the irrigation system were estimated by eye.

It should be noted that some loss of precision is expected using this method. The following is a list of possible areas where accuracy is expected to have been lost during the mapping and ditch length calculations (for a discussion on the precision of the Zippin Method see Zippin, 1958);

1. During mapping, loss of resolution is expected due to channel complexity (i.e. bends, widths, braiding), resulting in an underestimate of actual channel length (all cases).

2. For ditches which could not be traced completely from air photos, hand drawn approximations may result in either over- or under-estimations of channel length (Gavelin, Shackan systems, Hanna and Neale).
3. Air photos were taken in 1979 for all but one system (Shackan #1-4, 1966) and subsequent changes either through erosion or changes by the rancher may not have been significant enough to be noticed during ground-proofing of the maps (all systems underestimated).
4. The complexity of some systems (i.e. Shulus #2) and time constraints resulted in insufficient time to walk all channels, so some error in channel mapping may result.
5. The use of the map-wheel to estimate the length of the ditches from the map drawings is not the most accurate method available and is expected to result in an underestimate of channel lengths (all systems).

In summary, these sources of error are likely to lead to an underestimation of channel lengths. As a result, all population estimates may be underestimates and represent a minimum estimate of fish rearing within each channel section and irrigation system.

RESULTS AND STATUS OF IRRIGATION DITCHES

During the 1985 surveys, a total of 12 irrigation ditch systems were examined and mapped and an additional 5 systems were identified from conversations with Department of Fisheries and Oceans (DFO) and Provincial Ministry of the Environment, Fisheries Branch (MoE-FB) personnel. Other small irrigation systems may exist throughout the valley.

i) Neale Ranch: Location: 6 km downstream of Merritt on the south side of the Nicola River (Figure 1).

Despite the presence in the irrigation channel of a 'Finnigan-type' fish screen, located approximately 500 m downstream from the intake site, fish still managed to enter the system. This channel was probably the major site of chinook and rainbow trout losses in the 1985 surveys due to dewatering of irrigation channels during the winter.

The intake site from the Nicola R. was an open-channel with no head-gate structure for flow regulation. DFO files indicate that a maximum of 6 cfs is licensed for withdrawal purposes. A coarse fence structure was in place to prevent large debris from entering the irrigation channel and to allow the damming of the channel with plywood, etc. for dewatering purposes. A diversion is usually constructed across the Nicola River during low flows, to provide adequate water for irrigation ditch operation. In 1985, a low flow year, this diversion consisted of an embankment of gravel and assorted debris across 80 - 90 percent of the Nicola River.

From the intake area, the irrigation channel runs parallel with the Nicola River for approximately 500 m to where an 8' X 8' Finnigan screen was located. The screen seemed to be working adequately in 1985 but may need some minor repairs to the seams, which appeared to be partially separated. At this point, some of the flows are diverted into a bypass culvert, enabling fish to return to the river. The irrigation channel continues to parallel the Nicola River to a point approximately 10 - 20 m downstream of its confluence with Lindley Creek (Figure 2), where it begins to follow a path along the edge of the hay fields.

Lindley Creek is a small, temporary stream which dries up completely during the summer. It empties into the irrigation ditch and is subject to diversions for irrigation purposes upstream of this creek-ditch confluence during periods of sufficient flow. An open culvert, with a small dirt-gravel dam across its opening to prevent water outflow during average flow conditions, was located opposite the creek confluence to allow extreme flows from the creek and/or irrigation channel to enter the river (a "safety valve"). During high water levels in the Nicola River, this may be an access point for juvenile fish to enter the irrigation system while seeking refuge from high river flows.

The irrigation ditch had periodic breaches in the channel banks to allow water to flow into the field(s). A pump-house was located near the ranch buildings with a small pond which may act as an overwintering area for some fish. The channel, heavily overgrown with bankside grasses, continues through the property, branching off at various points to form secondary channels or to simply flood sections of the hay fields. These "flooded" fields may be major sites of fish mortalities during irrigation ditch operation, as generally fish cannot re-enter the ditch channel due to gradient restrictions and are subject to increased water temperatures and dewatering situations. At the lower (downstream) end, the ditch appeared to have been extended (in 1985) into the furthest field and may, under extreme flow conditions, connect with a beaver pond and the river, at the lower end of the ranch. However, no salmonids were observed in the beaver pond during minnow trap sampling in August 1985.

Despite the presence of a rotating screen on the Neale Ranch irrigation ditch, this system contained approximately eight times the total number of chinook and an equal number of rainbow trout, captured in all other irrigation systems combined during the last sampling period (Table 1). A total of 4,100 ± 400 chinook and 3,738 ± 693 rainbow trout were estimated to be present downstream of the fish screen (2,034 m wetted channel length) when dewatering occurred just prior to the October 4th visit. This is expected to be a conservative estimate of fish losses for the total irrigation period, as no estimate was made of salmonids trapped in the large areas of flooded pasture land in July and August. Both chinook and rainbow were electrofished from one of these areas on August 19, but no quantitative data are available. It was further estimated that an additional 647 chinook and 465 rainbow were rearing in the channel upstream of the fish screen (Table 1). The large swamp, which occupies an area in the middle of the irrigated fields, is not connected directly to the irrigation ditch, and minnow trapping indicated that no fish were present.

Chinook, rainbow, suckers and dace were the most common species observed during the 1985 sampling surveys. Coho, mountain whitefish, redside shiners, lamprey ammocoetes and sculpins were present in low numbers. It was

likely that the fish screen, if operational, would effectively prevent any fish movements into or out of the channel during summer and fall. No access through the culvert was possible during this period.

Upstream reaches of the irrigation channel had larger chinook and rainbow than the lower reaches (Table 2). Chinook made up 28% of the salmonid catch on August 19 and 58% on September 18.

ii) Shulus Irrigation Systems: Location: originating from Guichon Creek approximately 3.5 - 4.5 km upstream of the confluence with the Nicola River; terminating on the north side of Highway 8, about 4 km west of Merritt. (Estimated total length 26,583 m)(Figure 1).

There are three irrigation systems in this area (Figure 3). Shulus #3 has not been used in recent years but may be reactivated in the near future. Shulus #2 had been dewatered during the first survey on September 6 and no fish were captured during sampling on October 1. Both Shulus #2 and Shulus #3 irrigate Shulus Indian Reserve pastures.

Shulus #1, a privately operated irrigation system, diverts water from Guichon Creek approximately 3.5 km above the Nicola River confluence and passes through a pine-wooded area as a clean fast-flowing channel before entering the pasture and hay fields bordering Highway #8. Its terminal point is at the north side of the highway, but during September sampling only two-thirds of the ditch was wetted. It is a single channel with no apparent branches or breaches in the channel banks and passes through two small ponds, one with an irrigation pump-house, before the water disappears through seepage into the channel bed. The ditch does not appear to be dewatered during the summer months as its main purpose seems to be to service the pump-house rather than direct irrigation.

Sampling on October 1, 1985 indicated that an estimated 687 chinook and 1,114 rainbow (3,201 metres of wetted channel length) were rearing within the irrigation ditch (Shulus #1) (Table 3). In addition, smaller numbers of suckers, dace and chiselmouths were also captured. The two ponds were not sampled but would be the likely habitat of any coho rearing within the irrigation ditch. The mean length of chinook and rainbow were 84.9 and 92.5 mm respectively (Table 5). Analysis of scales from a total of 15 chinook, ranging from 75 to 99 mm, showed that all were 1+, indicating a second year of freshwater growth.

Carcasses of adult chinook salmon were observed in Shulus #1 during the survey period on both September 6 and October 1 and 2. Spawning was unlikely in the ditch, and carcasses were probably spent spawners which had been carried downstream and diverted into the irrigation ditch.

iii) Shackan Irrigation Ditches: Location: approximately 39 km downstream from Merritt on the Nicola River (Figure 1).

Shackan #1 is located on the north bank of the Nicola River upstream of the Shackan Indian Reserve, opposite Agate Creek (Figure 4). It is an extensive irrigation system, diverting water from the Nicola River into a slow-flowing intake channel with no head-gate control structure at the river entrance. A control structure was observed approximately 800 m downstream just before the ditch begins to branch into a series of smaller, fast-flowing channels which terminate in a hay field. Large sections of the hay field were

flooded during high flows in June and early July.

Sampling in Shackan #1 on July 26, 1985 indicated that both chinook salmon (n=4) and rainbow trout (n=33) were present (Table 6) as well as numerous small dace and suckers (channel length sampled = 70 m). On August 6, 35 rainbow but no chinook were captured in 120 m of channel. A population estimate indicated that 656 ± 96 rainbow were rearing in the upper 800 m of ditch (Table 7). No estimate is available for the lower 2000 m, where water movement was more evident. In both cases, the majority of individuals were captured in the slow-moving intake channel and in the shallow pool habitats in the downstream end of the irrigation channels. On September 3, the channel had been dammed by beavers (third day in a row) during the night. One redside shiner and a rainbow trout (110 mm) were observed in the mud downstream of the beaver dam along with a few dace and rainbow trout in scattered puddles along the drying channel bed. On October 3, electrofishing downstream of a second beaver dam (downstream of the first) produced 200 - 300 rainbow trout (45 - 60 mm) in a 40 m x 1 m x 0.1 m section of drying ditch.

Shackan #2 is located along the south bank of the Nicola River and receives its water from Shackan Creek. The water is carried along an extensive trough and trestle system before it branches into two channels (Table 8). On August 8, a total of 35 rainbow trout were electrofished from a single-pass in 25 m length of channel, before it had entered the hay field. Additional individuals were captured in a channel in the field but it was too heavily overgrown for any quantitative sampling. There were extremely low flow conditions at this time. Sampling in the same area on October 4 produced no captures in 60 m of channel length. It was assumed that flows had ceased sometime in August with a total loss of all individuals rearing in the system.

Shackan #3 consists of two systems, each originating from Skuhun Creek and branching off on either bank. Shackan #3b (Figure 4) on the east bank of Skuhun Creek provided rearing habitat for approximately 1672 rainbow trout on October 3. At this time, since it was no longer being used for irrigation purposes, it had been diverted back into the creek. A few rainbow (30+) were observed stranded in the channel downstream of the diversion.

Shackan #3a (Figure 4) branches off the west bank of Skuhun Creek upstream of Highway #8 and irrigates a small area in the village of Shackan (Indian Reserve). It also receives some flows from a natural spring originating below the highway. Sampling on October 3, 1985 indicated that approximately 2,215 rainbow trout were present (Table 7).

Shackan #4 (A-Joe Road, 14 Mile Ranch) is located on the north bank of the Nicola River and receives its water from the natural springs originating in the village of Shackan (see Shackan #3a). No fish were captured in the irrigation ditch or the beaver pond which it drains (electrofishing July 26 and October 4; minnow trapping October 18 [pond]), suggesting that there is no fish-passage connection between the springs and Shackan #3a, although a few fish had been observed in other years by the rancher. The outlet channel from the beaver pond to the Nicola River (site 2), however, contained rainbow, coho and chinook (Table 6), probably emigrants from the river during higher stage levels.

iv) Gavelin Ranch: Location: 11 km downstream of Merritt, located on the south bank of the Nicola River (Figure 1).

The major diversion (Gavelin #2), occurs immediately downstream of the railway bridge and the channel crosses approximately 250 m of field before reaching a Finnigan screen (installed in 1973) (Figure 5). At the screen, the fish exit through a culvert back into the Nicola River and the screened water is channeled down an extensive array of ditches criss-crossing the fields. Electrofishing carried out downstream of the screen on August 8, 1985 produced only a small number of suckers and dace (<25 mm) indicating that the screen was working effectively. These fish would have passed through the fish screen when larvae. However, observations of the screen revealed that it was not operating independently and that it was being cleaned manually with a broom by the rancher (pers. comm. with Mr. Gavelin). Maintenance problems included worn brushes on the paddlewheel (no replacement parts were available), the outlet channel was beginning to silt in, and an erosion problem was developing at the boarded channel that carried the outflow to the culvert. Electrofishing in the ditch upstream of the screen indicated both chinook and rainbow utilized the ditch for rearing purposes (Table 9). There was some indication of emigration of chinook, as densities decreased between July and August sampling periods (Table 10).

Gavelin #1 is a small unscreened irrigation ditch which originates approximately 400 m upstream of the Gavelin #2 intake. It runs along the edge of the Nicola River for approximately 300 m, at which point it is diverted inland. Sampling indicated that both chinook in low densities and rainbow trout in moderate densities were present in August (Table 10), but no chinook were captured in September. The total ditch length is 5022 m (Table 11).

v) Strand Ranch: Location: 19 kilometers above Merritt on the Coldwater River (Figure 1).

Two irrigation ditch systems were present at the Strand Ranch, one on each side of the Coldwater River (Figure 6). The Strand Ditch East had a headgate flow control structure at its intake. Approximately 379 m downstream, a Finnigan fish screen was operating. It appeared to be working adequately but some erosion and undermining problems may be developing. Electrofishing immediately downstream of the screen on August 23 resulted in the capture of a small number of rainbow trout. It is not clear if they passed through or around the screen. Since the ditch joins back into the Coldwater River some fish may migrate up into the channel. Some adult steelhead trout spawners were observed in the creek at the lower end (pers. comm. with rancher). The total length of the ditch is 2,457 m.

Strand Ditch West was not operating during the 1985 survey. The channels divert water from the Coldwater as well as Midday Creek, and form what appear to be sidechannels with several access points to the river before entering the fields. Formerly this system had a screen which became inoperable and was removed due to heavy siltation problems. Flows eroded the trap sides and formed a bypass channel around it. The total length of this ditch system is 2,241 m.

vi) Coldwater Ranch: Location: 24 kilometers above Merritt on the east bank of the Coldwater River (Figure 1).

The system consists of a long channel with a headgate at the diversion

(Figure 7). No water was flowing through this system during the survey period. Pole seining at the large shallow ponds at the end of the channel did not produce any fish. A screen installed in 1978 was "buried" during a flood, and a new screen near the headgate was installed during the week of November 11 - 16, 1985 (K. Conlin, pers. comm.). The total length of this ditch system is 2,667 m.

vii) Hanna Ranch: Location: immediately downstream of Merritt on the north bank of the Nicola River (Figure 1).

Hanna ditch consists of an open intake channel during high flows, supplemented by a pumping system during low flows (Figure 8). The ditch was not operating during the August 9 survey, however, juvenile dace and suckers , but no salmonids, were found in small isolated pools located in the drying channel bed. This system also connects to channels on the neighbouring ranch which did not appear to have been used during the 1985 season.

viii) Chutter Ranch: Location: just below Nicola Lake on the south bank of the Nicola River (Figure 1).

This site was not sampled during the 1985 survey. However, Eliasen (1979) describes the area as having two gravity flow ditches. The larger of the two systems has a 12' X 12' Finnigan screen located approximately 460 m downstream of the headgate. A 140 m bypass channel at the screen provides a route for fish to re-enter the Nicola River. The screen prevents passage of fish into ditches covering some 120 acres of hayfields. The ditch area from the headgate to the screen has shown some success as a rearing habitat (K. Conlin, pers. comm.).

ix) Nielson Pond

A small pond, located on the Neale Ranch (Figure 2), was constructed by the Department of Fisheries and Oceans in 1979 to improve rearing habitat. Originally the site of a natural groundwater-fed pond/creek, it has been "improved" by dredging the pond, adding a head-gate at the pond's outlet and installing sub-surface percolation chambers (infiltration gallery) to enhance flows into the pond.

Pole seining on July 16, 1985 in the outlet creek below the pond, obtained 5 rainbow trout. Electrofishing on August 19, 1985 produced one coho, 11 rainbow trout and an unspecified number of redside shiners, suckers and lamprey ammocoetes in a 5 m long section of the outlet creek. No salmonids were captured or observed in the pond itself.

x) Hanna Springs

A natural spring on the Hanna Ranch (Figure 8) appeared to be a very productive rearing habitat for chinook, coho and rainbow trout. Electrofishing on September 3 (Table 12) produced a sample of 78 coho (mean length 71.6 mm), 21 chinook (mean length 70.5 mm) and 61 rainbow trout (mean length 58.3 mm) in a 25 - 30 m section. Capture efficiency was very poor as a result of an unstable mud bottom, an inability to sample the deeper waters and copious instream cover.

Upstream of the spring, a pump house was located on a pond. No fish were observed in the pond probably due to small impassable barriers at the pond outlets.

xi) Shulus Springs

A natural spring on the Shulus Reserve (Figure 3) is another site with great potential for juvenile salmonid rearing and production. A sampling program in May 1985 (smolt fence and trap) on the outlet of Shulus Springs captured 273 coho smolts (Stewart 1985). A large beaver pond located near its downstream end probably prevents extensive immigration into the spring through much of the year. Minnow trapping on September 5, 1985 showed that chinook, coho, rainbow trout, suckers, chiselmouth and redside shiners were present (Table 13). The chinook and rainbow rearing in the spring upstream of the beaver pond appeared to be larger and healthier than those individuals captured in the pond or the slough into which the pond drains.

xii) Lower Nicola

The Lower Nicola site is a small diversion branching off the east bank of Guichon Creek just north of Highway #8 (Figure 1). This ditch was not closely examined during the 1985 survey. The ditch consists of a small channel which branches into two channels. One branch enters a back-yard of a nearby house, while the other is directed into a small field.

A diversion dam which extended into Guichon Creek may have partially impeded salmon and trout migrating upstream to spawn, although several spawners were observed upstream of it. Chinook spawner carcasses were observed in the lower channels on October 17, 1985, probably washed down from Guichon Creek. Ditch flows vary with creek flows although there is a crude head gate control. Pole seining at the intake on September 5, 1985 resulted in the capture of one coho, 3 chinook and 11 rainbow trout. I. MacGregor (MOE-FB, per. comm.) indicated that several other irrigation ditch systems exist in the Guichon Creek drainage system.

DISCUSSION

i) Location, Timing and Operational Procedures

Irrigation ditches usually begin operating in the late spring when increasing snow melt produces high river discharges. High discharges between April and July coincide with the emergence from the gravel of chinook, coho and rainbow trout fry. As a result young fish are either passively carried into or actively seek refuge in ditches during this critical dispersal stage of their life. Further movements of fish into ditches probably continues throughout the summer as falling water levels and normal downstream dispersal behaviour cause juvenile fish to enter ditch intake areas. High velocities in entrance channels are likely to prevent smaller fish from swimming upstream and back into the river. Studies on irrigation systems on the Columbia River suggest that velocities $\geq$15.2 cm s^{-1} are sufficient to draw salmon fry into intakes (Swan et al. 1986). As flows decrease, this mid-summer immigration may be exacerbated by the construction of wing dams across the river, which have been observed to span 80 - 90 percent of the wet river bed (e.g. Neale Ranch). The wing dam does provide a situation where fish may seek out and are directed towards ditch areas as suitable habitat. The location of the ditch intake along the shoreline of

the river places it in an area where the juvenile fish are most likely to be located in their initial rearing stage and during high velocities. The intake site becomes a continuation of the river bank for the fry rearing and dispersing downstream along the river's edge. Fish may also be attracted to the cooler water of ditches, especially if they are spring fed (Levings et al. 1985.

An irrigation ditch is typically composed of an extensive system of channels continually branching as it moves downstream, often with considerable velocities in some sections making upstream movements difficult for smaller fish. A typical method of irrigating the hay fields is to breach the ditch bank and allow the water to flood a portion of a field. The high summer temperatures soon warm the water causing oxygen depletion and eventually the mortality of any fish entering the field. Ditches are often constructed at an elevation higher than the surrounding fields so that the resulting hydraulic difference is a barrier to fish trying to re-enter the ditch from the field. Breaches in the ditch bank are usually temporary so that other parts of the field can be watered and the flooded section dries until the next time it is flooded. Large numbers of fish may be lost during this process, as was observed at Neale Ranch.

Some ditch systems are completely dewatered two or three times per irrigation season so that haying can occur. The initial fish population is lost immediately but whether subsequent immigration into the ditch is inhibited or enhanced is unknown. Additional problems such as beaver activity may result in a channel being blocked and drying up in a single night (eg. Shackan #1), thereby preventing any fish from rearing in the ditches and emigrating out into the river either naturally at the end of the season or under controlled conditions.

Several studies of fish behaviour in flow reduction situations were carried out in the Nicola Valley irrigation ditches during the mid-1970s (Tutty MS 1975; Finnigan 1975; Russell memorandum 1978). These studies generally found that the natural response of the fish to a drop in ditch water levels was to emigrate either upstream or downstream. Tutty (MS 1975) speculated that the majority of fingerlings would outmigrate from a small channel naturally before freeze-up, a view supported by observations during 1985 in one of the smaller channels (Gavelin #1). Tutty also suggested that if proper escape avenues were provided for the fish (e.g. portable fishway) at head-gate closures, and adequate screening of the secondary channels was installed, during the dewatering period in the summer a rancher could allow a considerable portion of the fish to vacate the irrigation system by simply reducing flows slowly over a 24 h period. A rapid drop in water level, but leaving enough flows to allow upstream migration, would also elicit a similar response (Finnigan 1978). This would allow the ditches to be used for rearing purposes while not causing extensive fish mortality. This would appear to be a sound idea, but relies heavily upon the rancher to take a continuing interest in fisheries concerns. The ditch would require a flow control structure (head-gate) and any barriers to upstream migration, such as culverts,hydraulic drops and beaver activity, would have to be accounted for if such a program were attempted.

ii) Fish Populations in Ditches

During 1985, several ditches were identified as areas of high density salmonid rearing and eventual fish-loss due to dewatering. The Neale ditch was estimated to contain the greatest number of salmonids, with a total of 4,100 *400 chinook salmon and 3738 *693 rainbow trout (Table 2) estimated to have been

lost in early October when flows were cut off. No individuals are expected to have emigrated out as the fish screen would act as a barrier to upstream movements. These totals are considered to be minimum estimates of the numbers of fish in the ditch at the time of dewatering. Total fish loss in the ditch over the season was probably much higher.

Shackan ditches #1, 2 and 3 all appear to affect considerable numbers of rainbow trout. Accurate figures of fish densities prior to dewatering are unavailable. However judging from the numbers of fish observed in Shackan #1 and Shackan #3 (a and b) during sampling in October, the large flooded field sections during June/July in Shackan #1 and the total loss of all individuals in Shackan #2, trout fry losses would be considerably greater than the approximately 4500 rearing trout estimated during October sampling.

Sampling in Shulus #1 indicated 687 chinook and 1114 rainbow trout juveniles were present in October. Two ponds in the lower reaches of the ditch may have increased the total population. The ponds may also provide overwintering habitat. Shulus #2 may affect similar numbers of salmonids.

The Gavelin ditches do not appear to present any major threat to fish. Gavelin #2 provides approximately 250 - 300 m of rearing channel upstream of the fish screen. A decrease in numbers of chinook in both ditches was observed during sampling over the summer, possibly due to emigration from the irrigation channels as the fish increase in size.

Previous estimates of fish populations rearing in these ditches are not comparable with those generated in 1985. Previous sampling (Anon MS 1951; Anon MS 1955) involved many ditches no longer in operation. Sampling by Russell (MS 1978) in 1978 was focussed on ditches along the Coldwater River (no active unscreened ditches were operating during the 1985 survey); and sampling by Tutty (MS 1975) and Finnigan (1978) was in Gavelin #2 which now has an operating fish screen.

Tutty (pers. comm. with Starr, MS 1978) found juvenile chinook captured in the fall of 1974 in Gavelin's ditch were extremely healthy and exceptionally large. 1974 was a low flow year and Starr proposed that in this case the ditches provide a stable refuge with high productivity, compared to the main river. In 1976, a high flow year, Starr (MS 1978) found that juvenile chinook from Gavelin's irrigation ditch were significantly smaller than the main stream population taken from the river. He hypothesized that the ditches provided poor habitat and that salmonids found there were fish that could not compete in the river system. Russell (MS 1978) found that ditches appear to provide excellent rearing habitat and that densities were greater than in the adjacent river.

iii) Ditches as Rearing Habitat

Considerable rearing habitat can be gained by proper placement of screens. Knowledge gained from both the successes (e.g. Gavelin, Strand East, Chutter), as well as the failures (Coldwater, Strand West), can help any future screening plans so that rearing habitat can be maximized while the screen's installation and operation problems are minimized.

Finnigan (1978) attempted to use an infiltration gallery as a water source for an irrigation ditch, thereby making an open-channel intake

unnecessary. The experiment was not successful as the method provided insufficient water for irrigation and there was some fish entry into the gallery. This might be useful, however, in the utilization of ditches as rearing habitat after a rancher has switched to a pump and sprinkler system. The ditch could be closed off at its upper end to prevent erosion and maintenance problems and opened to the river at the lower end. The infiltration gallery would supply a constant water supply in much the same way as the Nielson Pond and vastly increase potential juvenile rearing area by providing small channels between the oxbows of the river.

The springs on the Hanna Ranch and at Shulus appear to be very productive rearing sites. Sites such as these should be maintained and possibly simulated in other parts of the valley. Some enhancement, particularly improvement of fish access to and from the river, may be needed. Many of the ditches offer small, easily controlled situations where experimental studies, similar to the dewatering experiments of the mid-1970s, can be carried out. Fish behaviour, habitat preferences, growth, inter- and intra-specific competition and possibly some toxin/fish response experiments are but a few topics that could be examined in this semi-natural habitat.

SUMMARY

1. A total of 12 irrigation ditches were examined during the 1985 field program. Five were no longer in operation during field sampling activities at those sites. An additional five were identified by means other than direct visits.

2. The Neale Ranch irrigation system, despite the presence of an operating fish screen, showed the greatest potential loss of rearing salmonids. A total of 4100 chinook salmon and 3738 rainbow trout juveniles were estimated to have been present in the irrigation system and downstream of the fish screen at the time of dewatering. During the 1985 irrigation period probably 2-3 times more fish were lost.

3. Despite the relatively low densities of fish observed in the single ditch sampled in the Guichon Creek system, this system may be a major source of fish losses, as the total length of the ditches is extensive.

4. There are significant opportunities in the Nicola Valley for rearing habitat enhancement by using the upstream parts of screened ditches, improving use of the downstream portions of abandoned ditches and capitalizing on natural springs that are part of some irrigation systems.

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Table 1. 1985 population size (lower panel) and density (upper panel) estimates of chinook and rainbow trout in Neale Ranch irrigation ditches.

Date	Sample site	Sampled length (m)	Sample width (m)	Estimated density of chinook (per m)	Estimated density of rainbow (per m)
850918	1	14.3	0.7	9.748 ± 1.14	3.215 ± 1.11
	2	22.0	0.8	0.731 ± 0.03	1.066 ± 0.08
	3	10.3	0.8	1.073 ± 0.05	3.610 ± 0.09
	4	13.7	0.9	2.392 ± 0.45	2.234 ± 0.42
	5	15.1	0.6	1.798 ± 0.06	1.069 ± 0.42
	6	13.8	1.2	2.376 ± 0.43	2.167 ± 0.46
	8	17.0	1.5	1.251 ± 0.21	0.900 ± 0.61

Date	Sample Site	Representative Length (m)	Population Estimate of Chinook	Population Estimate of Rainbow Trout
850918	2 & 3	552	995 ± 22	1291 ± 47
	4	172	401 ± 76	384 ± 72
	5	707	1271 ± 42	756 ± 297
	6	603	1433 ± 259	1307 ± 277
Total		2034	4100 ± 400	3738 ± 693
	8	517	647 ± 109	465 ± 315
Total		2551	4747 ± 509	4203 ± 1008

Table 2. Catch and length data for salmonids in Neale ranch irrigation ditches.

Date	Method	Site	Species	No. captured	No. measured	Mean length (mm ± S.D.)
850716	PS[1]	8	CH[3]	19	16	47.8 ± 4.8
	PS	ii	RBT[4]	5	5	29.2 ± 4.1
850819	ES[2]	2,4	CH	23	23	52.5 ± 4.4
			RBT	57	57	46.4 ± 5.5
	ES	8	CH	6	6	62.8 ± 5.8
			RBT	18	18	48.8 ± 6.6
			CO	1	1	70.0
			RBT	11	11	57.3 ± 7.2
	ES	ii	CO[5]	1	1	70.0
851004	ES	2,4	CH	72	72	57.0 ± 7.4
			RBT	54	54	48.8 ± 5.2
	ES	8	CH	29	29	69.0 ± 9.5
			RBT[6]	44	44	52.3 ± 7.0
			RBT[7]	1	1	155.0
			CO	1	1	58.0
			MWF[8]	1	0	
851018	ES	2,3,	CH	57	54	59.5 ± 7.0
			RBT	88	60	51.6 ± 7.4
		1	CH	123	44	56.1 ± 6.8
			RBT	37	0	
		6,8	CH	50	50	74.4 ± 7.1
			RBT	34	34	59.7 ± 6.7
			RBT	5	5	145.8 ± 28.3

1 Pole seine
2 Electrofisher
3 Chinook
4 Rainbow trout
5 Coho
6 0+ age class
7 1+ age class
8 Mountain whitefish

Table 3. 1985 population (lower panel) and density (upper panel) estimates for chinook and rainbow trout in Shulus irrigation systems.

Date	Sample site	Sampled length (m)	Sample width (m)	Estimated density of chinook (per m)	Estimated density of rainbow (per m)
Shulus #1					
851001	1	23.2	3.0	0.129	0.264 ± 0.04
	2	28.3	1.8	0.035	0.334 ± 0.08
	3	19.1	1.1	0.512 ± 0.16	0.922 ± 0.24
	4	20.8	1.1	0.482 ± 0.02	0.148 ± 0.43
851002	5	32.5	1.5	0.061	0.031
	6	18.0	2.6	0.439 ± 0.20	0.069 ± 0.14
	7	25.0	1.7	0	0.200
Shulus #2					
851001	1	38.6	2.2	0	0
	2	46.5	2.7	0	0

Date	Sample Site	Representative Length (m)	Population Estimate of Chinook	Population Estimate of Rainbow Trout
Shulus #1				
851001	1	942	122	249 ± 38
	2	765	27	256 ± 61
	3	541	277 ± 87	499 ± 130
	4	400	193 ± 8	59 ± 172
	5	259	16	8
	6	118	52 ± 24	8 ± 17
	7	176	0	35
Total		3201	687	1114

Table 4. Wet lengths and total lengths of ditches in Shulus irrigation systems.

Ditch System	Wetted length at time of sampling (m)	Total ditch length (m)
Shulus #1	3201	5459
Shulus #2	unknown	15529
Shulus #3	dry	4706
Lower Nicola	unknown	889
Total ditch length		26583

Table 5. Catch and length data for salmonids in 1985 sampling, Shulus irrigation systems.

Date	Method	Site	Species	No. captured	No. measured	Mean length (mm ± S.D.)
Shulus #1						
850716	ES	2	CH	15	14	87.2 ± 5.7
			RBT	10	10	82.7 ± 9.4
			RBT	11	11	159.0
851001	ES	1,2,3	CH	13	12	83.8 ± 6.7
			RBT	31	28	89.0 ± 21.39
		4 to 7	CH	19	18	85.7 ± 7.8
			RBT	12	9	104.89 ± 29.37

Table 6. Catch and length data for salmonids in 1985 sampling in Shackan irrigation ditches.

Date	Method	Site	Species	No. captured	No. measured	Mean length (mm ± S.D.)
SHACKAN #1						
850726	E.S.	1	CH	1	1	59.0
			RBT	13	13	30.3 ± 3.97
		4	CH	2	2	53.5 ± 2.12
			RBT	20	20	28.2 ± 3.66
		2	CH	1	1	58.0
850806	E.S.	1	RBT	26	26	30.7 ± 5.09
			RBT	1	1	100.0
		4	RBT	8	8	33.4 ± 6.41
		3	No fish observed			
SHACKAN #2						
850808	E.S.	1	RBT	35	35	32.2 ± 3.07
851004	E.S.	1	No fish observed			
SHACKAN #3a						
850807	E.S.	1	RBT	93	64	39.0 ± 5.43
851003	E.S.	1	RBT	60	34	48.6 ± 9.53
			RBT	3	3	117.0 ± 20.80
		2,3,4	RBT	61	41	43.0 ± 10.69
SHACKAN #4						
850726	E.S	1	No fish observed			
851018	M.T.	1	No fish observed			
851003	E.S.	2	RBT	12	12	54.1 ± 7.1
			CH	1	1	70.0 ±
			CO	3	3	67.0 ± 2.0

Table 7. Population (lower panel) and density (upper panel) estimates for chinook and rainbow trout in Shackan irrigation systems.

Date	Sample site	Sampled length (m)	Sampled width (m)	Estimated density of chinook (per m)	Estimated density of rainbow (per m)
SHACKAN #1					
850806	1	35.0	1.5	0	0.820 ± 0.12
SHACKAN #3a					
850807	1	17.8	0.8	0	5.355 ± 0.22
851003	1	20.7	1.6	0	3.104 ± 0.18
	2	10.5	0.5	0	0.095
	3	6.6	0.8	0	7.623 ± 1.32
	4	15.4	0.4	0	0.655 ± 0.33
SHACKAN #3b					
851003	1	10.5	1.5	0	4.497 ± 0.10
	2	9.4	0.6	0	1.825 ± 0.10

Date	Sample Site	Representative Length (m)	Population Estimate of Chinook	Population Estimate of Rainbow Trout
SHACKAN #1				
850806	1	800	0	656 ± 96
SHACKAN #3a	1	380	0	1180 ± 68
	2	400	0	38
	3	100	0	762 ± 132
	4	360	0	236 ± 119
Total		1240	0	2215
SHACKAN #3b				
851003	1	250	0	1124 ± 25
	2	300	0	548 ± 30
Total		550	0	1672 ± 55

Table 8. Wet lengths and total lengths of ditches in the Shackan irrigation systems.

Ditch System	Wetted length at time of sampling (m)	Total ditch length (m)
Shackan #1	2800	4400
Shackan #2	unknown	2400
Shackan #3a	1240	1240
Shackan #3b	550	1000
Shackan #4	500	500

Table 9. Catch and length data for salmonids in Gavelin irrigation ditches.

Date	Method	Site	Species	No. captured	No. measured	Mean length (mm ± S.D.)
GAVELIN #1						
850808	E.S.	1 & 2	CH	11	11	54.3 ± 3.2
			RBT	31	31	44.8 ± 3.8
		3	RBT	24	0	
850920	E.S.	1,2,3	RBT	28	27	54.6 ± 7.4
GAVELIN #2						
850724	E.S.	1	CH	23	23	49.0 ± 5.1
			RBT	17	17	43.3 ± 11.3
850808	E.S.	1	CH	12	12	60.5 ± 9.0
			RBT	16	16	46.5 ± 6.3
		2	CH	4	4	54.5 ± 3.7
			RBT	2	2	40.5 ± 6.4
		3	No salmonids observed			

Table 10. Population (lower panel) and density (upper panel) estimates for chinook and rainbow trout in 1985 samples of Gavelin irrigation ditches.

Date	Sample site	Sampled length (m)	Sampled width (m)	Estimated density of chinook (per m)	Estimated density of rainbow (per m)
GAVELIN #1					
850919	1	22.8	1.2	0	0.630 ± 0.08
	2	13.0	1.3	0	0.736 ± 0.18
	3	29.2	0.8	0	0.171
GAVELIN #2					
850724	1	26.5	1.3	0.992 ± 0.28	0.639 ± 0.11
850808	1	25.0	1.3	0.525 ± 0.15	0.648 ± 0.04

Date	Sample Site	Representative Length (m)	Population Estimate of Chinook	Population Estimate of Rainbow Trout
GAVELIN #1				
850919	1	300	0	190 ± 24
	2	167	0	123 ± 30
	3	89	0	15
	Total	556	0	328
GAVELIN #2				
850724	1	244	242 ± 68	156 ± 27
850808	1	244	128 ± 37	158 ± 10

Table 11. Wet lengths and total lengths of ditches in Gavelin irrigation systems.

Ditch System	Wetted length at time of sampling (m) (unscreened)	Total ditch length (m)
Gavelin #1	556	1022
Gavelin #2	244	4000
Total ditch length		5022

Table 12. Catch and length data for salmonids in Hanna Springs. Total di-h length - 4667 m.

Date	Method	Site	Species	No. captured	No. measured	Mean length (mm ± S.D.)
850716	PS	2	CH	4	4	53.5 ± 5.7
			RBT	19	19	30.3 ± 3.5
850903	ES	1	CH	21	21	70.5 ± 4.7
			CO	78	78	71.6 ± 9.3
			RBT	58	58	55.9 ± 6.3
			RBT	3	3	105.0 ± 10.2

Table 13. Catch and length data for salmonids in Shulus Springs. Total ditch length - 4667 m.

Date	Method	Site	Species	No. captured	No. measured	Mean length (mm)
850716	P.S.	2	CH	10	-	-
			RBT	3	-	-
			MWF	1	-	-
850820	E.S.	4	CH	41	41	70.3
			CO	1	1	85.0
			RBT	17	14	55.0
850905	M.T.	1	CH	6	6	63.7
			CO	3	3	75.0
			RBT	4	4	55.3
		3	CH	22	22	62.6
			CO	1	1	65
			RBT	4	4	72.5
		5	CH	2	2	83.5
			RBT	3	3	126.3
		6	RBT	4	4	122.5

Fig. 1. Map of the Nicola and Coldwater River valleys showing general sampling areas visited in 1985.

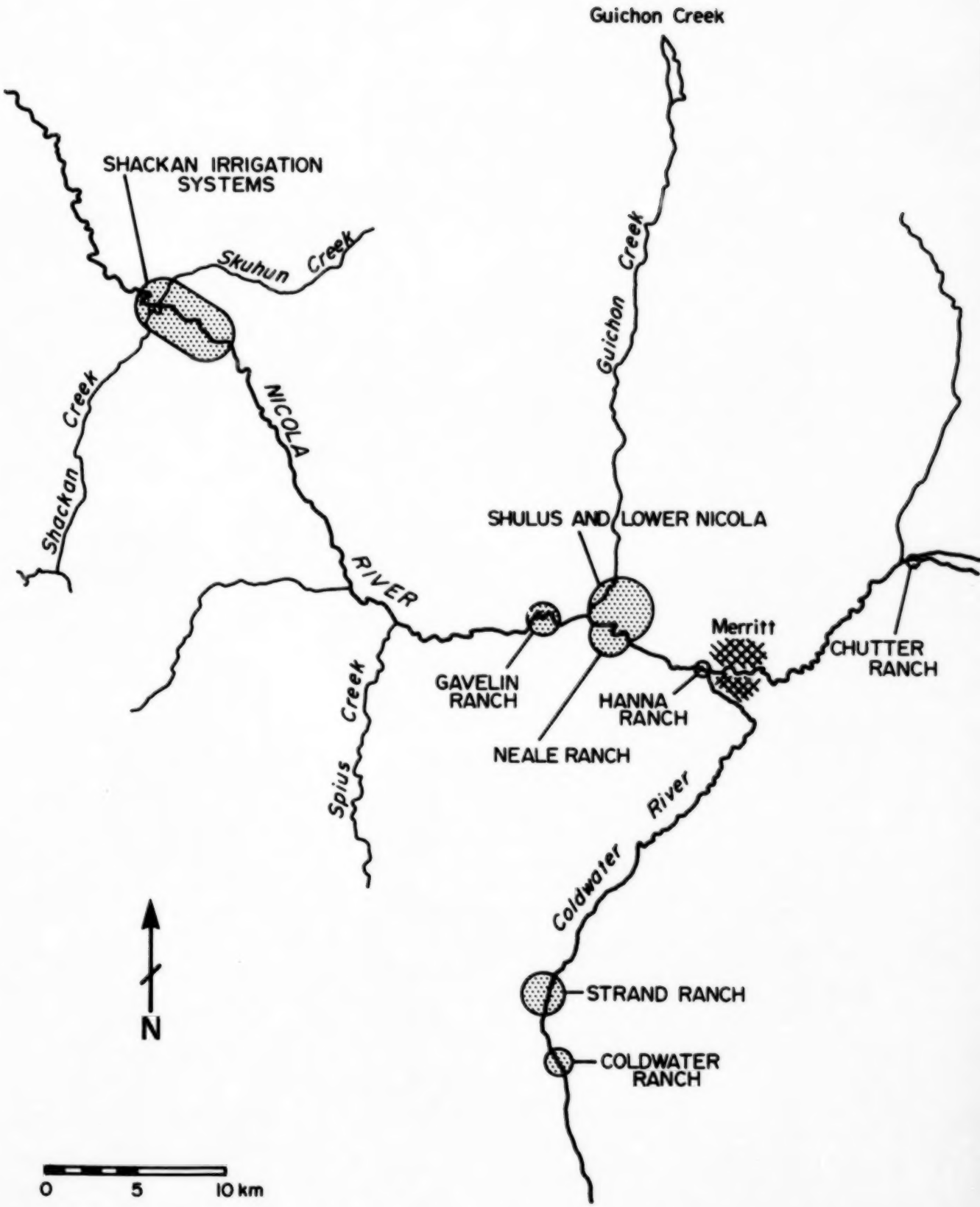

Guichon Creek
SHACKAN IRRIGATION SYSTEMS
Skuhun Creek
Guichon Creek
Shackan Creek
NICOLA
RIVER
SHULUS AND LOWER NICOLA
Merritt
CHUTTER RANCH
GAVELIN RANCH
HANNA RANCH
NEALE RANCH
Spius Creek
Coldwater River
STRAND RANCH
COLDWATER RANCH
N
0
5
10 km

Fig. 2. Map of the irrigation systems and sampling sites in the vicinity of the Neale Ranch on the Nicola River.

NEALE RANCH

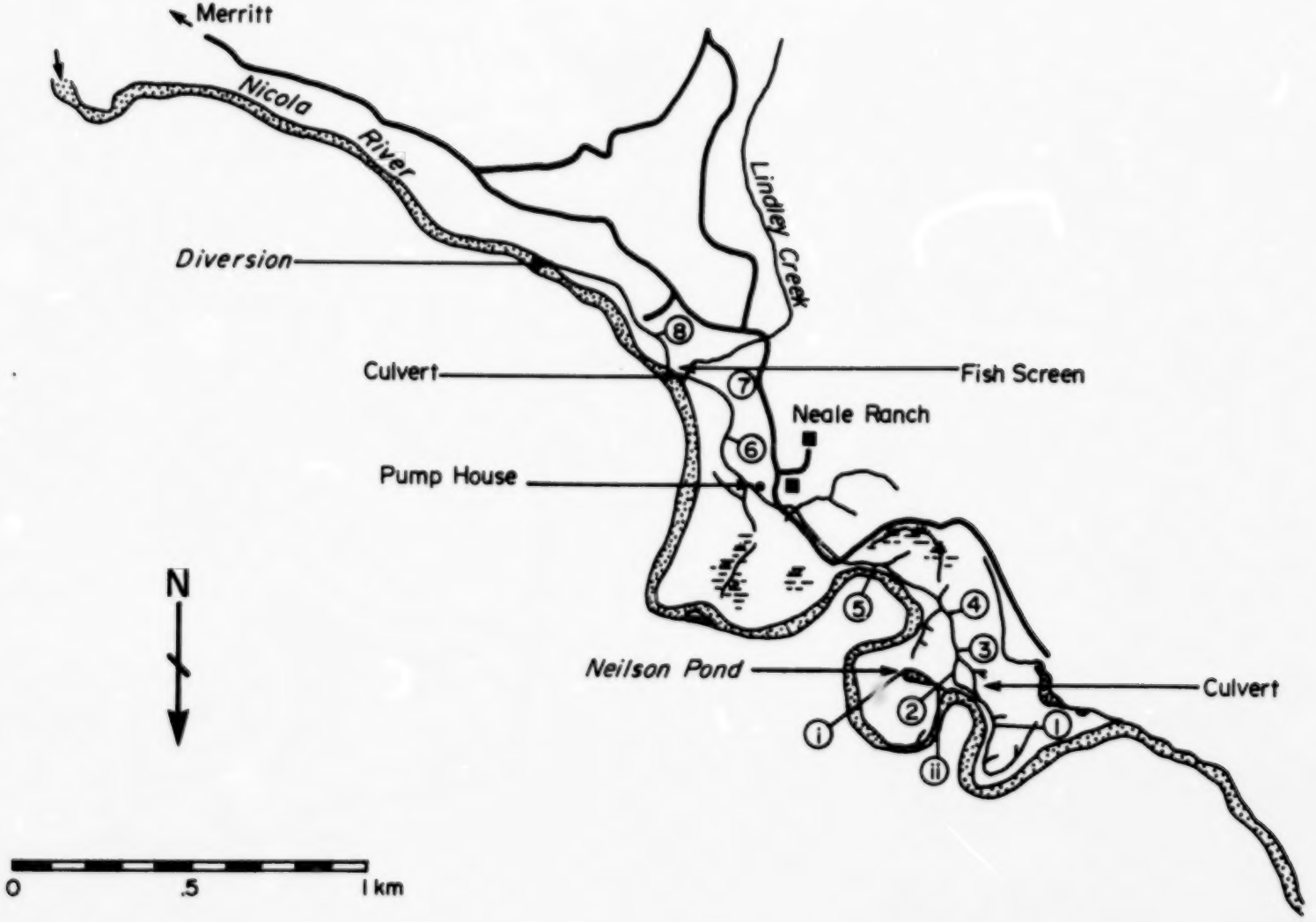

Merritt
Nicola River
Lindley Creek
Diversion
Culvert
Fish Screen
Neale Ranch
Pump House
N
Neilson Pond
Culvert
0
.5
1 km

Fig. 3. Map of the irrigation systems, springs, and sampling sites in the vicinity of the Shulus Indian reserve near Merritt.

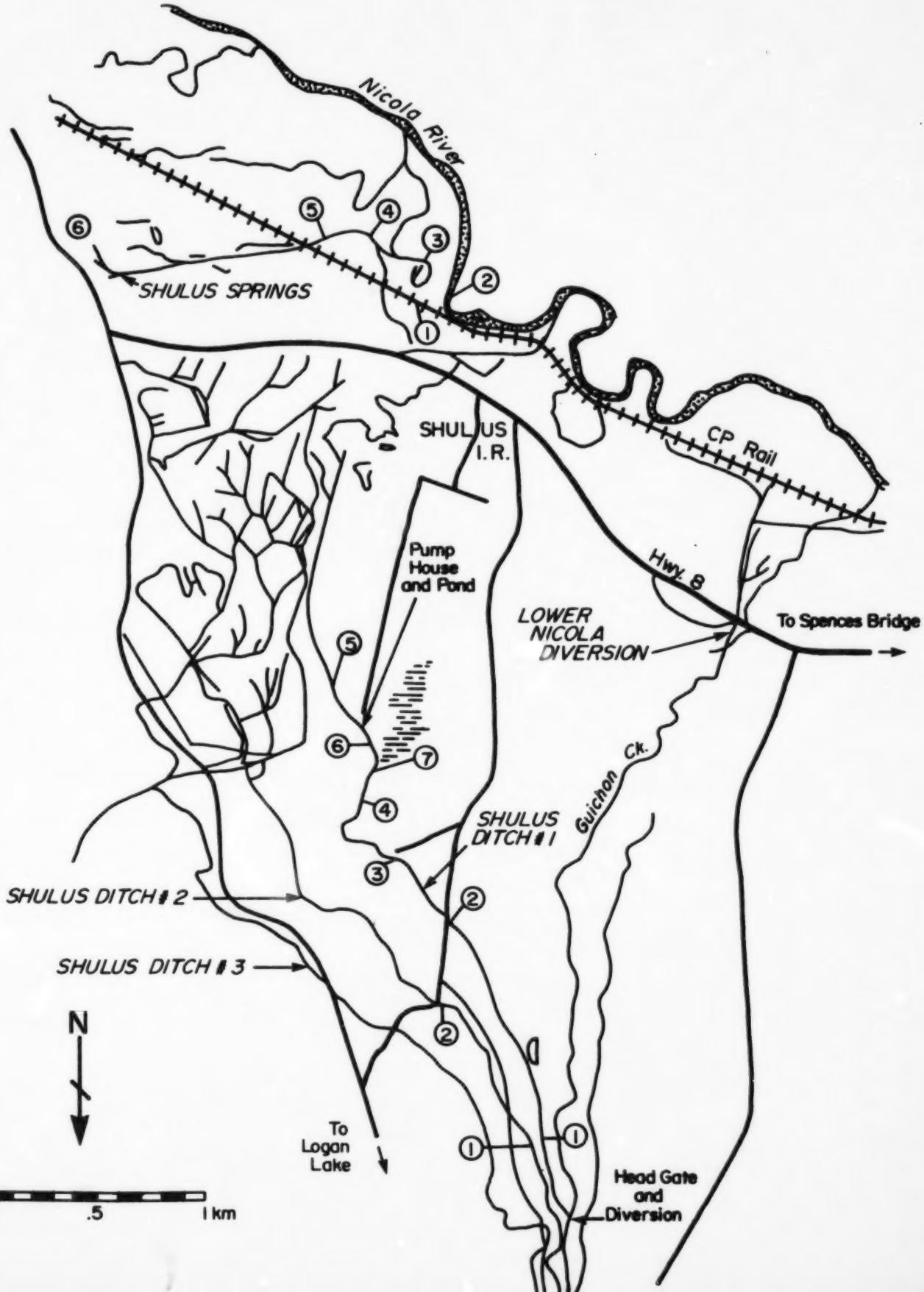

Nicola River
SHULUS SPRINGS
SHULUS I.R.
CP Rail
Hwy 8
Pump House and Pond
LOWER NICOLA DIVERSION
To Spences Bridge
Guichon Ck.
SHULUS DITCH # 1
SHULUS DITCH # 2
SHULUS DITCH # 3
N
To Logan Lake
Head Gate and Diversion
0
.5
1 km

Fig. 4. Map of the irrigation systems, creeks, and sampling sites in the vicinity of the Shackan Indian reserve on the lower Nicola River.

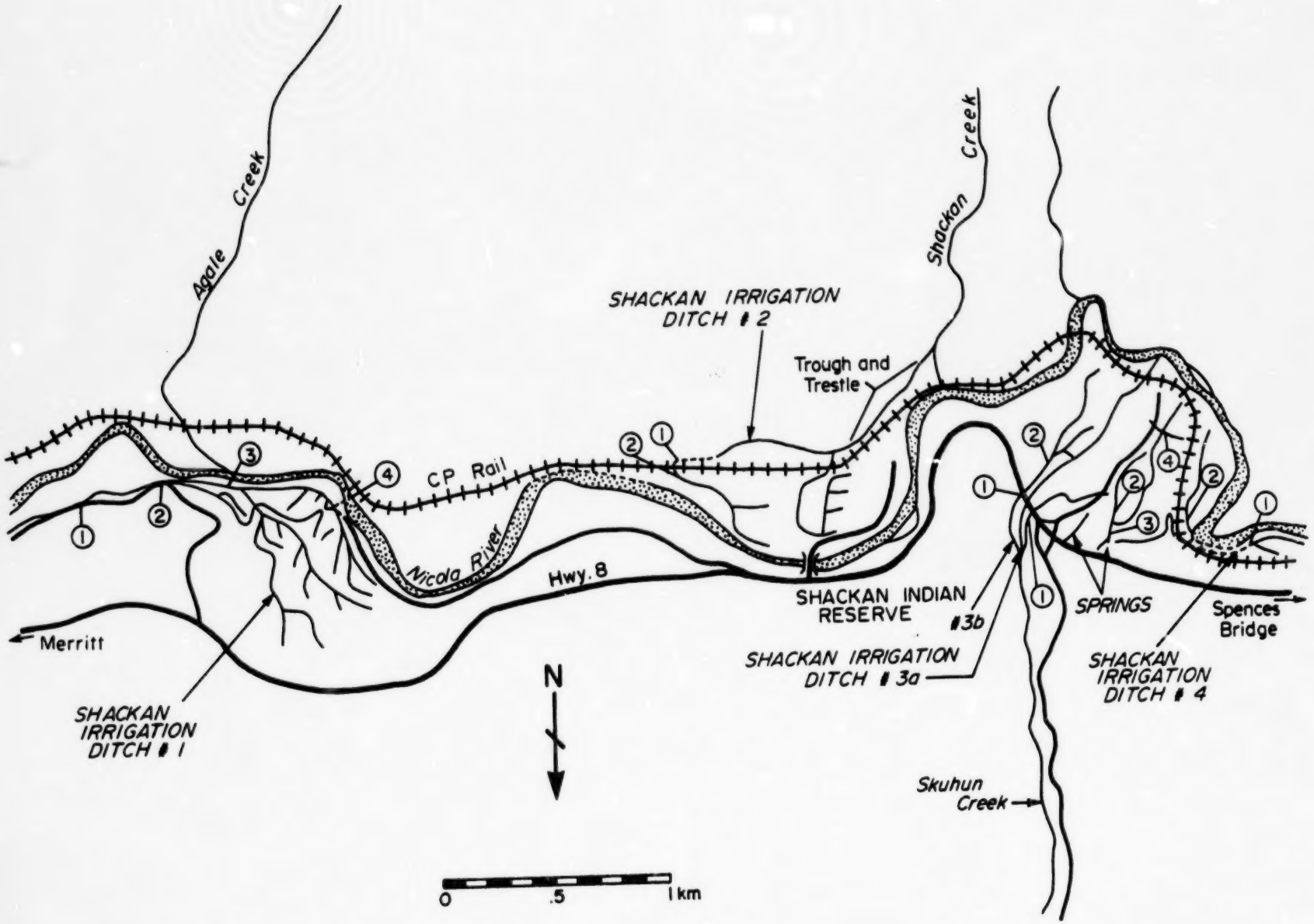

Aggie Creek
Shackan Creek
SHACKAN IRRIGATION DITCH # 2
Trough and Trestle
CP Rail
Nicola River
Hwy. 8
SHACKAN INDIAN RESERVE
#3b
SHACKAN IRRIGATION DITCH # 3a
SPRINGS
Spences Bridge
SHACKAN IRRIGATION DITCH # 4
Merritt
SHACKAN IRRIGATION DITCH # 1
N
Skuhun Creek
0
.5
1 km

Fig. 5. Map of the irrigation systems and sampling sites in the vicinity of Gavelin Ranch near Merritt.

GAVELIN RANCH

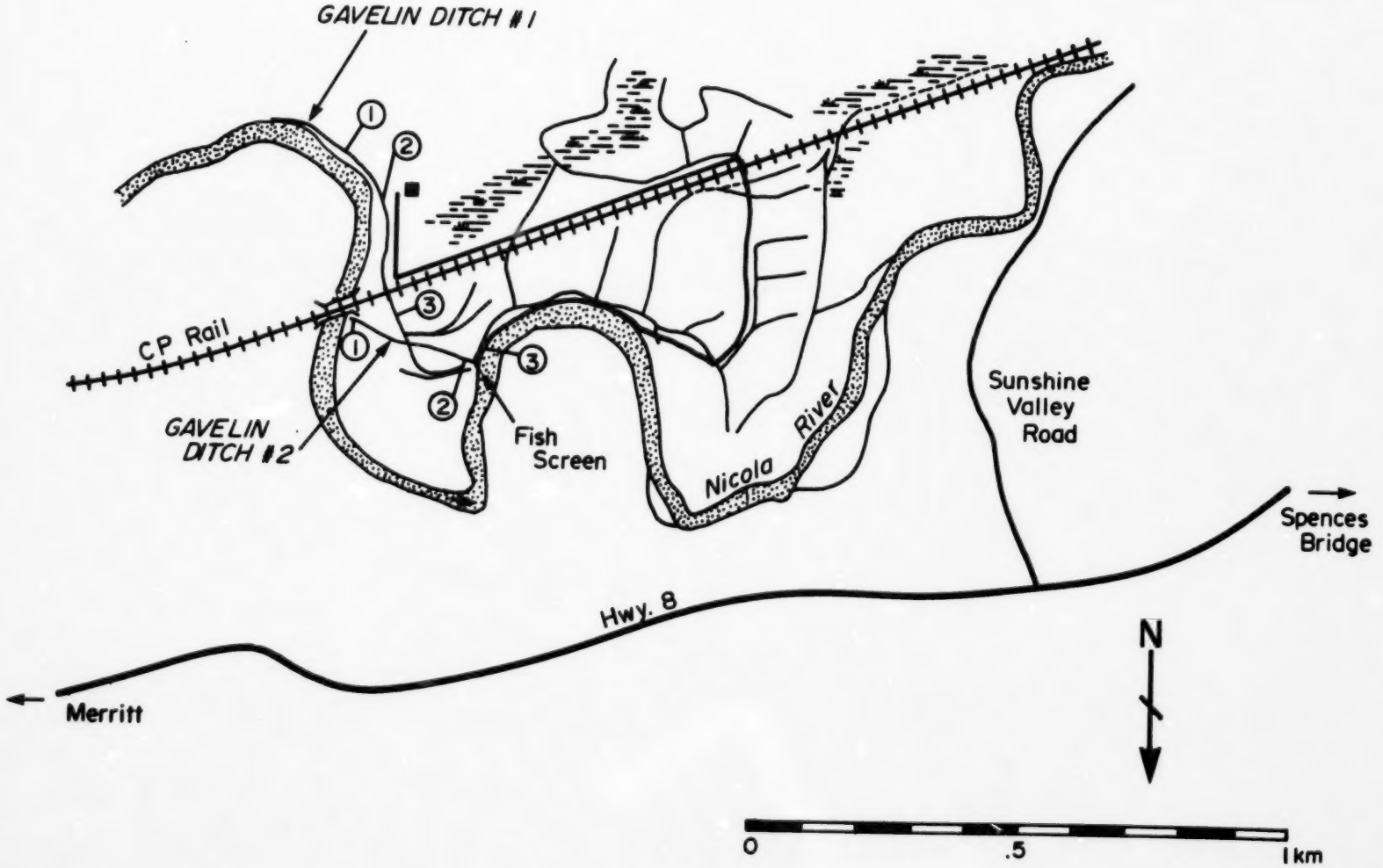


Fig. 6. Map of the irrigation systems and sampling site in the vicinity of the Strand Ranch, Coldwater River valley.

STRAND RANCH

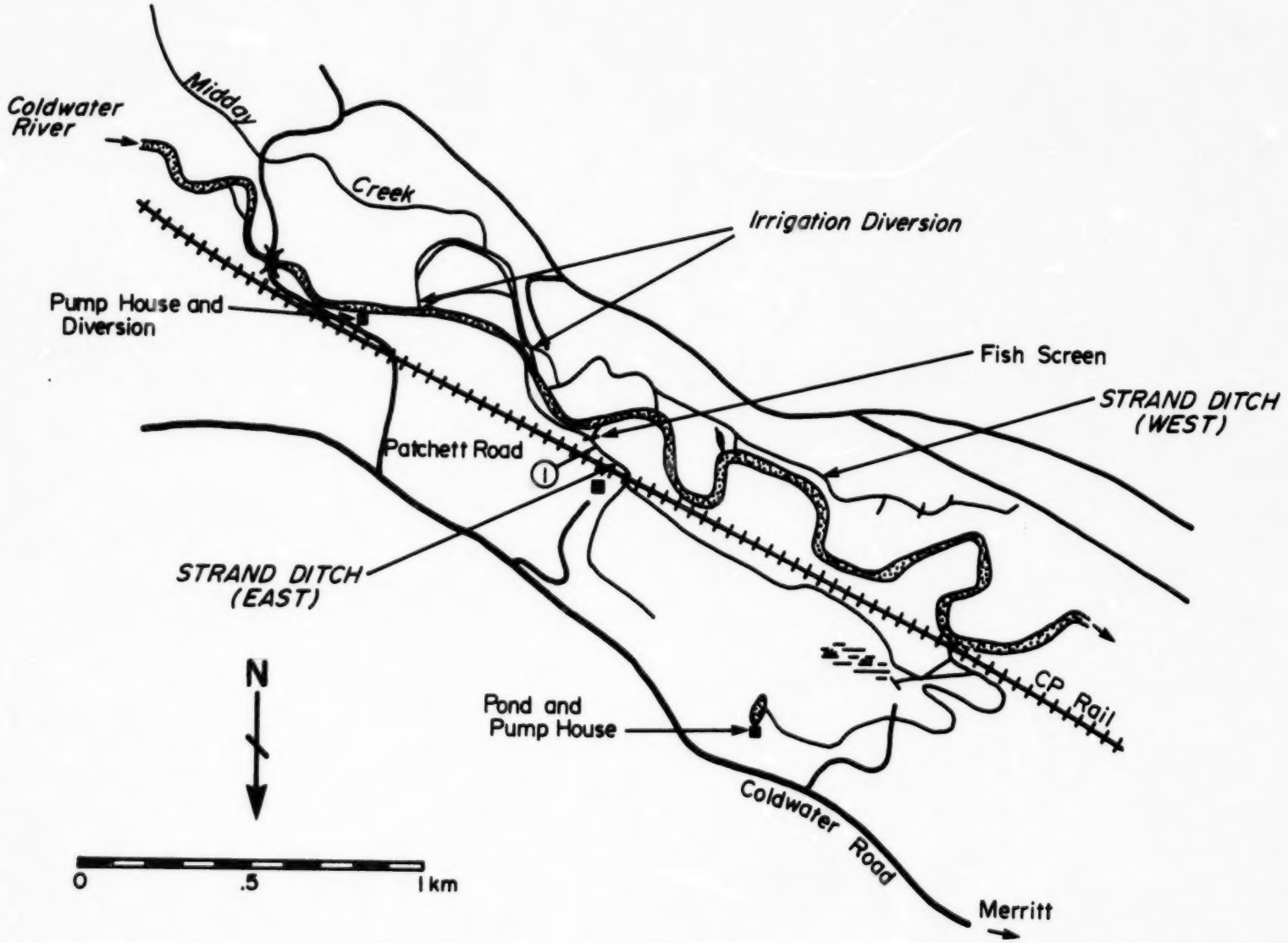


Fig. 7. Map of the irrigation systems in the vicinity of the Coldwater Ranch, Coldwater River valley.

COLDWATER RANCH

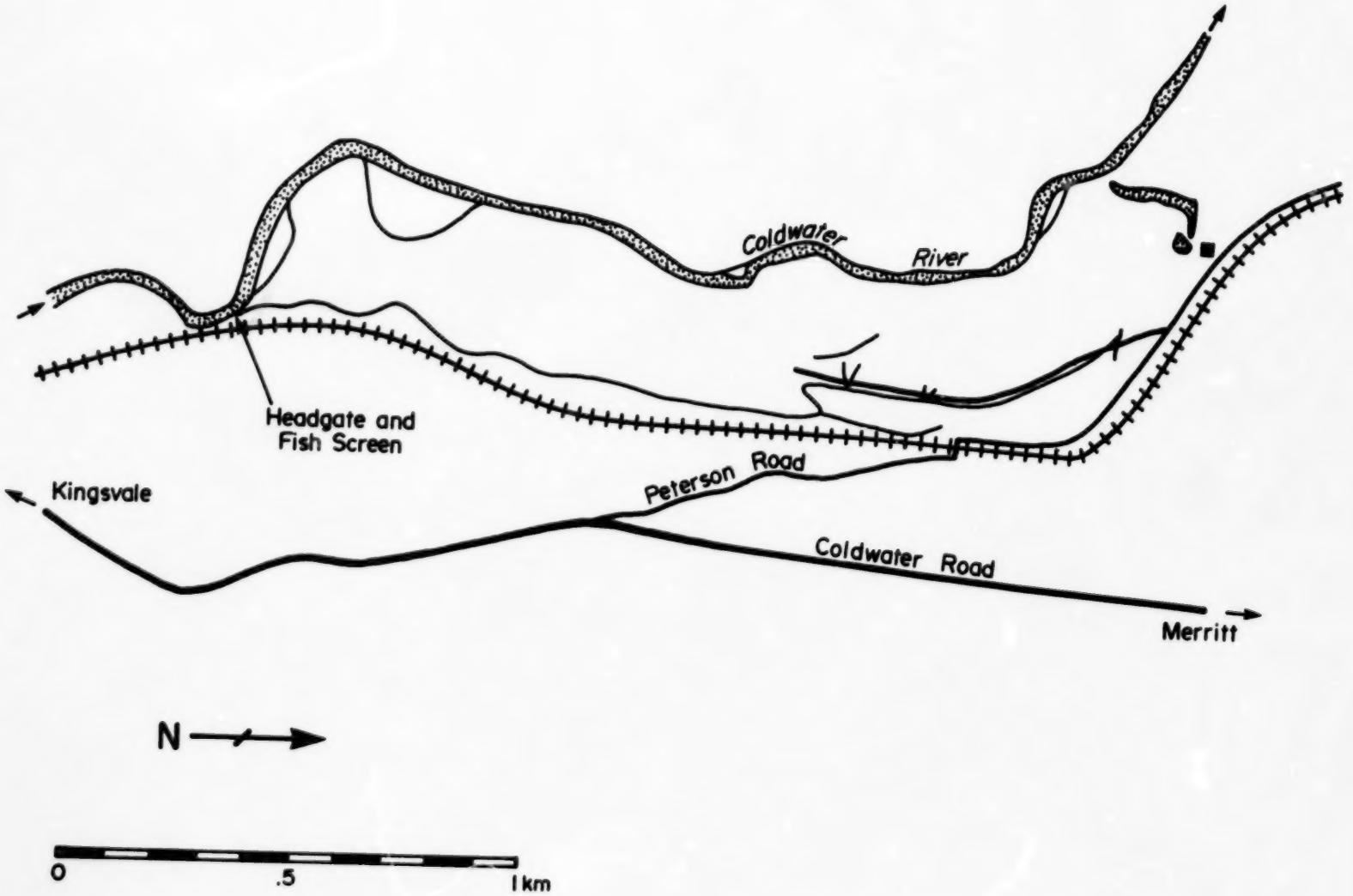
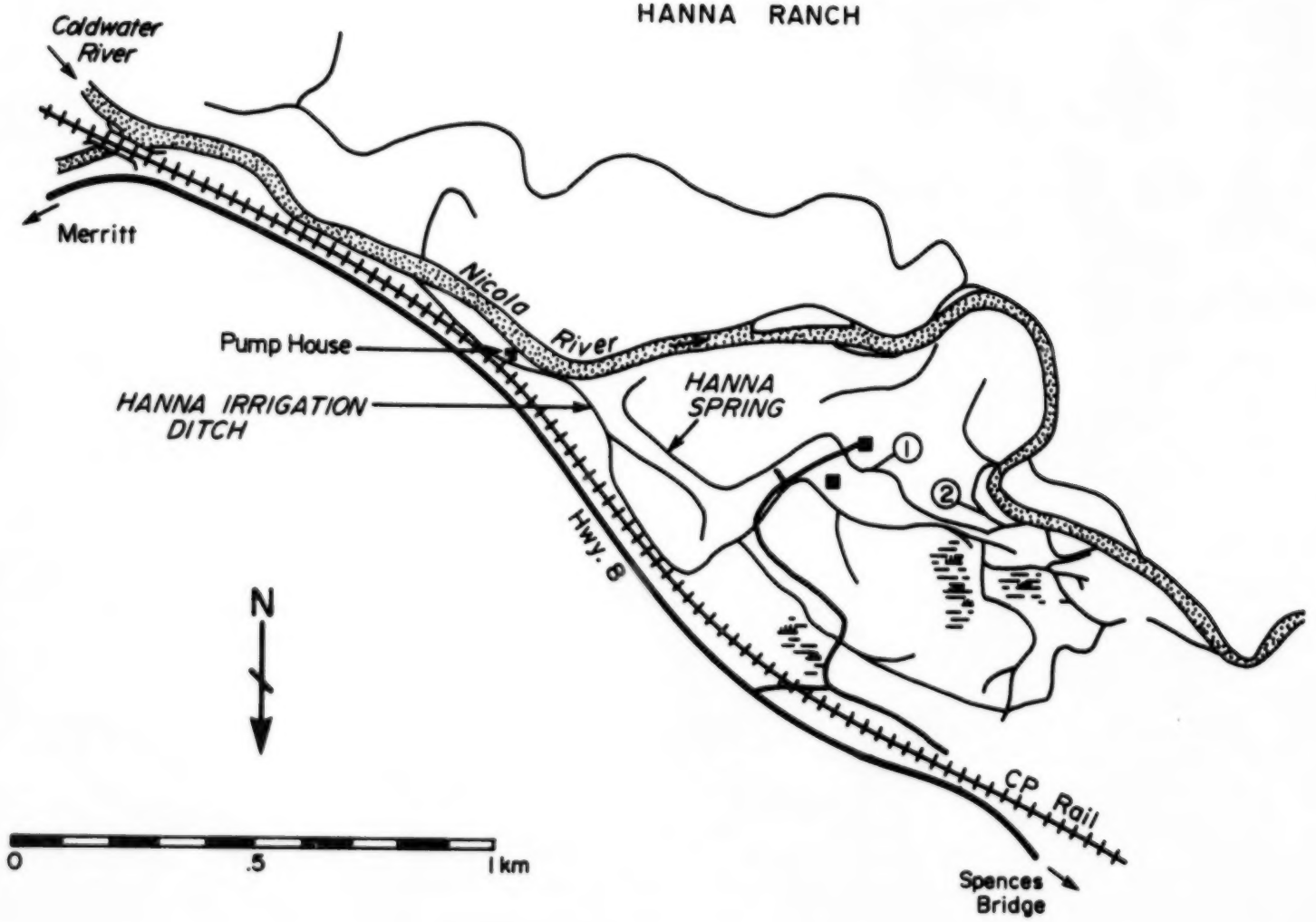


Fig. 8. Map of the irrigation systems, springs, and sampling sites in the vicinity of the Hanna Ranch on the Nicola River near Merritt.


HANNA RANCH
Coldwater River
Merritt
Nicola River
Pump House
HANNA IRRIGATION DITCH
HANNA SPRING
1
2
Hwy. 8
N
0
.5
1 km
CP Rail
Spences Bridge

Appendix 1. Irrigation systems, air photograph series and identification number used for mapping purposes.

Irrigation system	Air photograph, Series and number	Year
Neale Ranch	BC 79052 No.175	1979
Shulus #1,2,3	BC 79052 No.266	1979
Lower Nicola Diversion	" " " "	"
Shulus Springs	" " " "	"
Gavelin Ranch	BC 79052 No.269	1979
Shackan #1,2,3,4	BC 5196 No.107	1966
Hanna Ranch	BC 79052 No.177	1979
Strand Ranch	BC 79152 No.052	1979
Coldwater Ranch	BC 79124 No.166	1979
Not mapped:		
Chutter Ranch	BC 79052 No.259	1979